DISPERSION STRENGTHENED EXTRUDED METAL PRODUCTS SUBSTANTIALLY FREE OF TEXTURE

The present invention relates to dispersion strengthened extruded metallic products substantially free of texture as well as for a method for producing such products. The method comprises extruding a billet of fine grain dispersion strengthened metallic powder material through a die having an internal contour such that the material is subjected to a natural strain rate which is substantially constant as it passes through the die.

BACKGROUND OF THE INVENTION

When metallic materials are extruded, the strain induced in the material is generally large, typically 2 to 4. When the metallic material is polycrystalline and is subjected to such large strains, it adopts a deformation texture wherein the grains of the material are oriented such that particular crystallographic directions are aligned parallel to the direction of working. Such textures can be modified by subsequent working and heat treatment, but the material rarely regains a random crystallite orientation. In as much as crystallite orientation is influential on both the directionality of the physical properties of bulk materials as well as the response to processes of microstructural modification, such as recrystallization and grain growth, there exists a need to develop methods for extruding metallic materials so the extruded product is substantially free of texture.

SUMMARY OF THE INVENTION

In accordance with the present invention there is provided extruded dispersion strengthened metallic products which are substantially free of texture.

In preferred embodiments of the present invention the extruded product is comprised of (a) one or more metals selected from the high melting metals such as yttrium, silicon and those from Groups IVA, VA, VIA, and VIII or the low melting metals such as those from Groups IB, IIB (excluding Hg), IIB (excluding yttrium), VB, IIA, IIIA (excluding boron), and IVA (excluding silicon) of the Periodic Table of the Elements, and (b) one or more refractory compounds selected from the group consisting of refractory oxides, carbides, nitrides, and borides. In still other preferred embodiments of the present invention the metal constituent as iron, nickel, or cobalt based and the refractory compound is yttria or $5Al_2O_3.3Y_2O_3$.

Also, in accordance with the present invention, is a method for producing such materials which method comprises extruding a billet of dispersion strengthened metallic powder material comprised of one or more metals and one or more refractory compounds, said powder material having a mean grain size less than about 5 microns and whose grain size is substantially stable at the extrusion conditions, through a die having an internal contour such that the material is subjected to a natural strain rate which is substantially constant as it passes through the die.

Such a die will have an internal contour such that the area of cross-section of the material as it is passing through the die conforms substantially to the formula:

$$A = \frac{A_o}{\left[1 + \frac{\dot{\epsilon}}{v} x\right]}$$

where

A is the area of cross-section at any point x along the major axis of the die orifice from its entry plane;

A_o is the area of cross-section of the billet;

$\dot{\epsilon}$ is the natural strain rate; and

v is the velocity of the ram of the extrusion press.

In one preferred embodiment of the present invention for producing the products hereof the material is extruded into a rod through a die whose internal contour substantially conforms to the formula:

$$R = \sqrt{\frac{R_o}{\left[1 + \frac{\dot{\epsilon}}{v} x\right]}}$$

where

R is the radius of the internal contour of the die at any given point x along the major axis of the die orifice from its entry plane;

$\dot{\epsilon}$ is the natural strain rate;

v is the velocity of the ram of the extrusion press; and

R_o is the radius of the billet.

In another preferred embodiment the material is extruded into a tubular shape through a die whose internal contour conforms substantially to the formula:

$$R = R_o \left[\frac{1 + \frac{R_o}{r_o} \frac{\dot{\epsilon}}{v} x}{1 + \frac{\dot{\epsilon}}{v} x}\right]^{\frac{1}{2}}$$

where

R is the radius of the internal contour of the die at any given point x along the major axis of the die orifice from its entry plane;

$\dot{\epsilon}$ is the natural strain rate;

v is the velocity of the ram of the extrusion press;

R_o is the outer radius of the billet; and

r_o is the radius of the mandrel.

BRIEF DISCUSSION OF THE FIGURES

FIG. 1 is a perspective sectional view of a die used to extrude rods in accordance with the present invention.

FIG. 2 is a cross-sectional view of a die used in the present invention for extruding rods wherein the internal contour of the die is illustrated.

FIG. 3 is a cross-sectional view of a prior art die which is conventionally used to extrude strengthened metallic powder material into rods.

FIG. 4 shows a partial cross-sectional view of an extrusion apparatus for extruding rods in accordance with the present invention.

FIG. 5 is a partial cross-sectional view of an extrusion apparatus for extruding tubes in accordance with the present invention.

FIG. 6 is a logarithmic plot of flow stress versus strain rate at various temperatures for an iron base oxide dispersion strengthened alloy designated MA956 and having a mean grain size of about one micron.